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Tectonic Structures and Lateral Heterogeneity of Poisson's Ratio in the Upper Crust

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Poisson's ratio (σ),
Tectonic heterogeneity.

Abstract

In this paper have been conducted an analysis of seismic velocity waves to determine Poisson' s ratio of the crust and its implications for the eastern Anatolian and east black sea bounded. The Pg and Sg wave arrival times of 235 data recorded by three stations was used to examine the geotectonics of the study area. The Pg and S wave velocity were determined as 5.506 km/s and 3.146 km/s, respectively for the whole study area. The Vp/Vs ratios were calculated as 1.727- 1.754 with an average of 1.740. Poisson' s ratio (σ=0.205) have been obtained for the whole study area. The greatest Poisons' ratio values were observed for KTUT, while the smallest was observed in the ERZN stations. The highest Poisson's ratio values were obtained in the north part, while the lowest σ values were obtained in the south of the study area. The obtained lateral seismic velocity and Poisson' s ratio changes indicate the lithospheric compression or strain effects of the East Anatolia Fault Zone (EAFZ) and Bitlis Zagros Suture Zone (BZSZ) in the near crust and the sub-crust tectonic disturbance. This study shows that tectonic structures and lithospheric inhomogeneity structures can be defined by the dynamic properties such as Poisson' s ratio of the near upper Earth crust.

1.Introduction

Seismodynamic changes near the surface, faults, and complex tectonic structures are formed by the heterogeneous elastic characteristic inside the upper crust and the unstable surface geology of the upper part of the upper crust. In this paper, the relationship between the tectonic structures, lateral tectonic discontinuities, rating of fault and the wave velocities and Poisson' s ratio manifested itself very effectively. Attenuation is on of the basic properties of seismic waves from which material and physical conditions in the Earth's interior can be inferred (Aki, 1980). The VP/VS quotients are actually widely used for research involving tectonics, such as active fault zones, fore arcs in addition to volcanoes (Chiarabba & Amato, 2003; Eberhart-Phillips, Reyners, Chadwick, & Chiu, 2005; Moretti, De Gori, & Chiarabba, 2009; Ojeda & Havskov, 2001). Lateral variations of VP/VS ratios are typically well correlated with tectonic and geological structures. The Poisson's ratios can be readily transformed from the P and S velocity ratios, VP/VS (Salah & Seno, 2008b), allowing for a wide analysis of VP/VS ratios (MacKenzie et al., 2008; Musacchio, Mooney, Luetgert, & Christensen, 1997). Poisson's ratio, as an elastic parameter, is the ratio between the radial shortening and the axial elongation. In comparison to the seismic wave velocities, Poisson's ratio is a much more useful indicator for the content of fluids and/or magma in crustal rocks (Aydın, 2016; Kayal, Zhao, Mishra, De, & Singh, 2002; Salah & Seno, 2008a; Salah & Zhao, 2003; Takei, 2002). The physical properties of the fault zone such as seismic velocity and Poisson's ratio as well as the distribution of cracks and fluids may have played an important role in the earthquake-generating processes (Kisslinger, 1996; Zhao, Mishra, & Sanda, 2002). The VP/VS capability will simply discover some sort of lateral deviation in lithology when the geological anomaly is found from the true portions (Sheriff, 1991). Poisson' ratio is diagnostic of the medium composition and properties such as lithology and rheology (Christensen, 1996; Fernández-Viejo, Clowes, & Welford, 2005; Rudnick & Fountain, 1995). Compared to Poisson's ratios, the seismodynamic properties can be a better indicator of the content of lithospheric compression.

2.Tectonic Settings and Seismology

Seismicity of Anatolian Block, including Turkey, is directed by three important tectonic blocks (Le Pichon & Gaulier, 1988; McKenzie, 1972; Şengör & Yilmaz, 1981). The northbound activity of the Arabian and African plate and Southbound activity of the Eurasian plate causes Anatolian Block to move towards West and Mediterranean approximately 20 mm a year by compressing the East section of the Anatolian block (Reilinger et al., 2006) The neotectonics of southern Anatolia began after the collision of Arabian and plates along the Bitlis-Zagros suture zone (Sengör & Natal'In, 1996). The collisional zone is also identified as a compressional–extensional tectonic regime, driven by the westward extrusion of the Anatolian plate along the right-lateral NAFZ and left-lateral EAFZ (Şengör & Yilmaz, 1981). The Eastern Anatolian contractionary zone, consisting of a collage of oceanic and continental crust, is an active collisional convergent zone that has still being squeezed between the Arabian and Eurasian plates (Fig. 1). Black sea is a Mesozoic-Early Cenozoic aged back-arc basin which is built behind northbound Tethys Ocean (Finetti, Bricchi, Del Ben, Pipan, & Xuan, 1988; Robinson, Rudat, Banks, & Wiles, 1996). Fig. 2 shows a map of the investigated area with the locations of the epicenters.

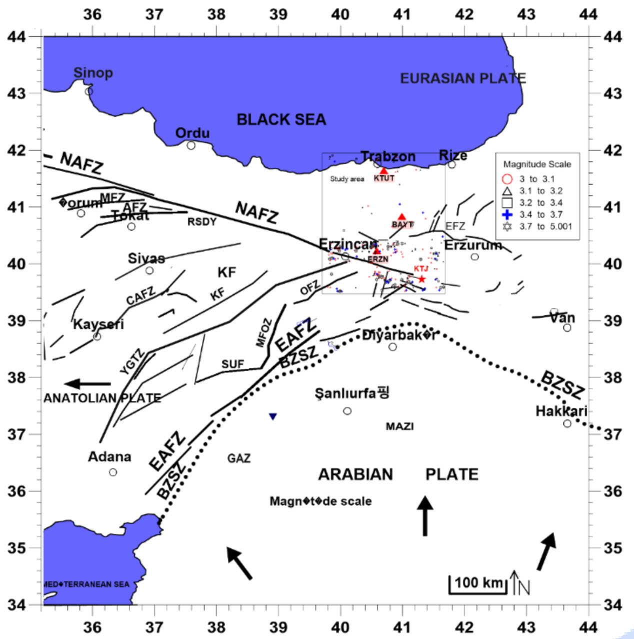


Figure 1. Simplified structural map of study area. The map shows the epicentral location of the earthquakes The three stations are shown with red triangles. Black lines represent faults and dotted lines are thrust faults. EAFZ–East Anatolian Fault Zone; NEAF-North-Eastern Anatolian Fault Zone; NEAFZ- North-Eastern Fault Zone; MOFZ - Malatya Ovacık Fault Zone.

3. Method and Data

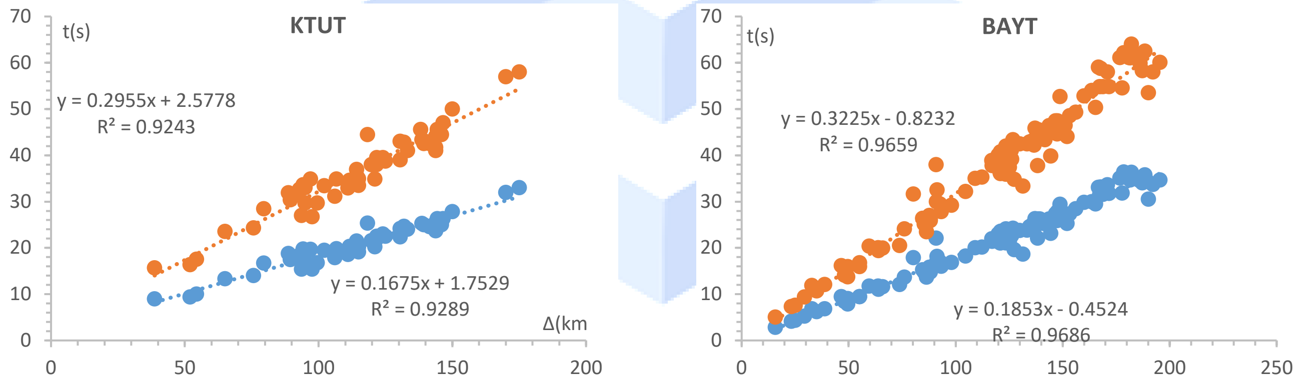
The relationship is used to determine the elastic parameter of Poisson's ratio (σ) (Utsu, 1984). By definition, Poisson's ratio is the ratio of radial contraction to axial elongation.

$$(v_p/v_s)^2=2(1-\sigma)/(1-2\sigma)$$ (Utsu, 1984)

where VP is the Pg wave velocity, VS is Sg wave velocity, σ is Poisson's ratio. Data used for this study were seismic records of the events recorded by three stations from Bogaziçi University Kandilli Observatory and Earthquake Research Institute (KOERI) (Fig. 2). The selected data set consists of 235 recorded with focal depth between 1 and 10.5 km, epicentral distance between 14 and 195 km and magnitude ranging between 3 and 4.8. In the study, 235 events and 291 data were used for the seismic velocities and Poisson's ratio (Tab. 1). Seismic wave phases were read in ZsacWin software and velocities were calculated using Excel.

4. Results

The Pg and Sg wave velocity value used in this study was calculated from 235 earthquake data used in this study (Fig. 1). The seismic velocities were calculated for the three stations and all work areas (Fig. 2). The body wave velocities and Poisson's ratios have been calculated separately for each station. (Tab. 1). The Vp/Vs ratio was calculated separately in each station to explore the lateral variation of upper crust tectonics (Fig. 2, Tab. 1). In the north of the study area (KTUT station) Poisson's ratio (σ) values were found 0.213. In the south of the study area (BAYT and ERZN) Poisson's ratio values were found between 0.184 and 0.156. The highest Poisson's values were observed in the KTUT station while the lowest values were observed in the ERZN station (Tab. 1, Fig. 2 and 3).



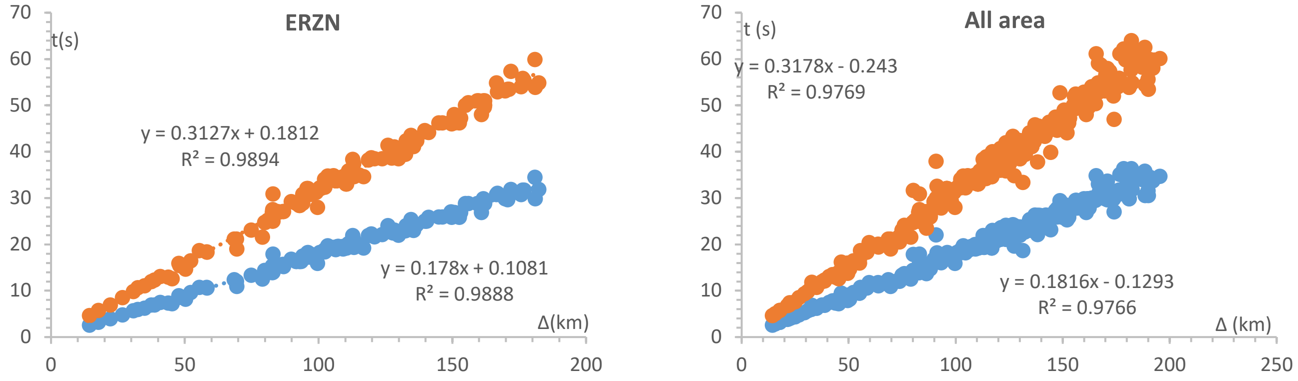


Table 1. VP, VS (P and S wave velocities), and σ (Poisson's ratio) calculated for the three studied sub-regions in southeast Anatolia.

No	Sta. Kode	Event	Mutual E.	Total E.	Latitude	Longitude	Vp (km/s)	Vs (km/s)	Vp/Vs	σ
1	KTUT	38	13	51	40.987	39.7667	5.698	3.248	1.7543	0.213
2	BAYT	81	22	103	40.3937	40.141	5.396	3.1	1.7406	0.184
3	ERZN	116	26	142	39.5867	39.722	5.316	3.077	1.7276	0.156
Average	----	----	----	----	----	----	5.470	3.141	1.7408	0.184
Σ	All area	235	61	296	----	----	5.506	3.146	1.7501	0.205

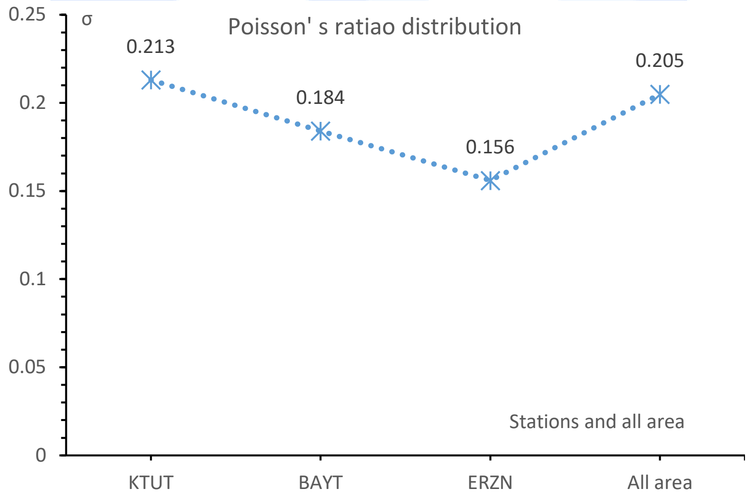


Figure 3. Comparison of the values for whole study areas and three stations.

5. Discussion

Poisson's ratio (σ) values were found 0.213 in the south of the study. The differences in the findings obtained from the study are remarkably significant. The Poisson ratio values showed a regular and gradual decrease from north to south. Poisson's ratio values in the north of the study area were high, while values in the south of the study area were low. This situation can be explained by the fact that the north parts of the study area are under a less intensive faulting regime than the south parts. Seismic velocity and Poisson's ratio have shown that the area in the southern part of the study region is more heterogeneous than the northern part of the region. (Fig 2). The Poisson' s ratio finding obtained for the study area as a whole, along with the three lateral findings, indicate the tectonic heterogeneity of the upper crust of the study area (Fig 4). Another effect for this spatial variation could be attributed to the different geological composition of the crust in these sub-regions. This work has once more indicated that the Poisson's ratio variation is related to the distinct tectonics structure and seismic activity of the upper crust.

6. Conclusions

The variations in Poisson's ratios are related to the geological uncertainties and fragility intensity of the upper crust. The seismic velocities as well as the Poisson's ratio ought to be changed according to the different tectonics properties of the upper crust and various pressured areas, which is because of the different physics properties and also kinematic properties of the upper crust. This study has shown that once again significant lateral variations of the crust elasticity and dynamic characteristics of the study field have been found to be associated with tectonic heterogeneity and elastodynamics within the upper crust.

Declaration of Conflict of Interests

The author declares that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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